EXPERIENCE WITH A SUBMERGED PIPE LINE IN THE PUERTO BARRIOS WATER WORKS[1]

By T. Howard Barnes

Puerto Barrios is the Atlantic seaport of Guatemala, the most populous of the Central American republics. For many years the rich interior sought a railroad connection to this outlet, finally realizing it in 1908. The president, Manuel Estrada Cabrera, recognized that the strip of sand-edged swamp called Barrios was destined to become important, and at the inauguration of the railroad in January, 1908, solicited a proposition for the complete sanitation of the port, that it might become in appearance, convenience and healthfulness, worthy of its importance as the eastern gateway of the republic. A substantial appropriation for the necessary studies and for provisional cleaning, ditching and other works of sanitation was made. The writer was designated to prepare the report and estimate of cost.

The report presented in the spring of 1909, called for about 3,000,000 cubic yards of filling, a sea wall, drains, sewers, water system, pavements and parks. The total cost proved too great for immediate execution. At the date mentioned, the terminal comprised a wharf, railroad station, round house, hotel, custom house, government house and a few scattered wooden residences, with a beach line of thatched cabins. The water supply depended upon rain-water cisterns and a 2-inch pipe well deriving water from a stratum of coarse sand 100 feet below the surface at a point about half a mile inland.

Natural growth of traffic and population brought the place face to face with a water famine, forcing the railroad company to introduce an adequate supply. The most available source was a mountain stream 7½ miles away, as measured by a practicable land line, or 5½ miles by a route in part across an arm of the bay. The submerged portion on the latter route was about 15,000 feet in length. The water attained a maximum depth of 24 feet. The bottom was

[1] **Read at the annual convention at Richmond, May, 1917.**

known to be of ooze. The land route involved several miles of swamp and rugged rock trench. The sea route led to fairly easy land connections.

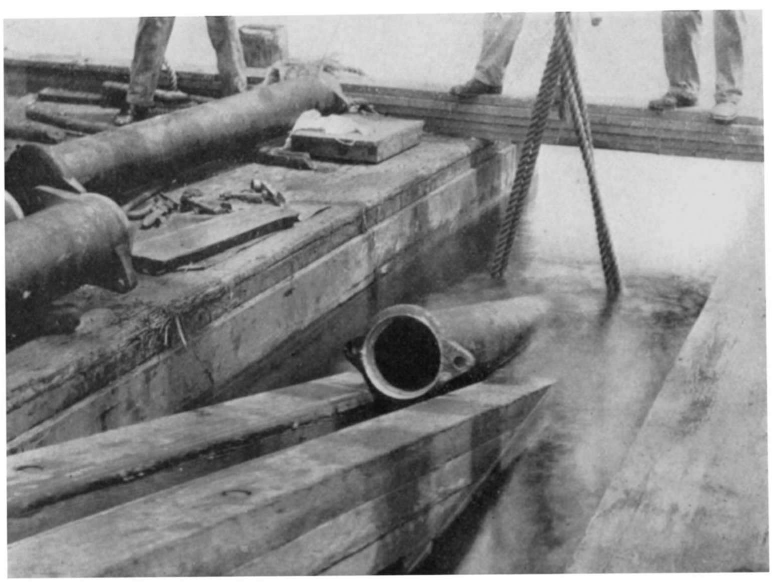
The all-land route involved an expense greater than seemed justified, while the cost of the shorter route would likewise be formidable should the submerged portion be laid with the ball-and-socket type of pipe joint. The size of the pipe demanded by the governing factors of quantity and pressure was 8 inches in diameter. The shorter route was chosen after investigation showed the Universal joint was adapted for continuous submerged pipe laying.

This joint, as is well known, is an iron-to-iron joint, only white or red lead being used in making it up. The pipe lengths are 6 feet. There are bulbous rings and ear lugs near the ends, which ends are machined in a lathe to certain exact tapers. The female taper is about 2½ degrees and the male slightly less. The pipes are held by bolts passing through the ears. There are two at each joint on pipe up to 16 inches in diameter, except that four are used for 12-inch and 16-inch pipe made for pressures exceeding 175 pounds per square inch. With two bolts a flexibility is obtained, when the tension on the bolts is moderate, in the plane vertical to the line passing through the two ears on any pipe. That is, a vertical movement is possible when the pipe is laid with ears in a horizontal position.

Tests were made regarding the extent of the flexibility and the behavior of the pipe when under water pressure. Eight 6-inch pipes were jointed and blocked up in line. Water was admitted and put under a pressure of 150 to 200 pounds per square inch. The blocking was removed in the middle, permitting a deflection of 8 inches in a five-pipe length, as measured from a chord at the center of bend. No resulting effect in loss of pressure ensued. The pipe was then deflected at the end piece until 4 inches was attained from a tangent extended from the adjacent piece, no leak ensuing. Slackening of bolts was tried, resulting in finding that a withdrawal of ⅛ inch produced a leakage of about two drops per second. These tests decided the use of this pipe and the adoption of the short route across the Bay. The same pipe was also adopted for the land portion of the line.

The method of laying was as follows: Two small deck lighters or floats were strapped side by side with about 6 feet clear space, forming a catamaran. A trussed trough tailing into a pair of long planks, and having a sliding way for paying off the pipe was sus-

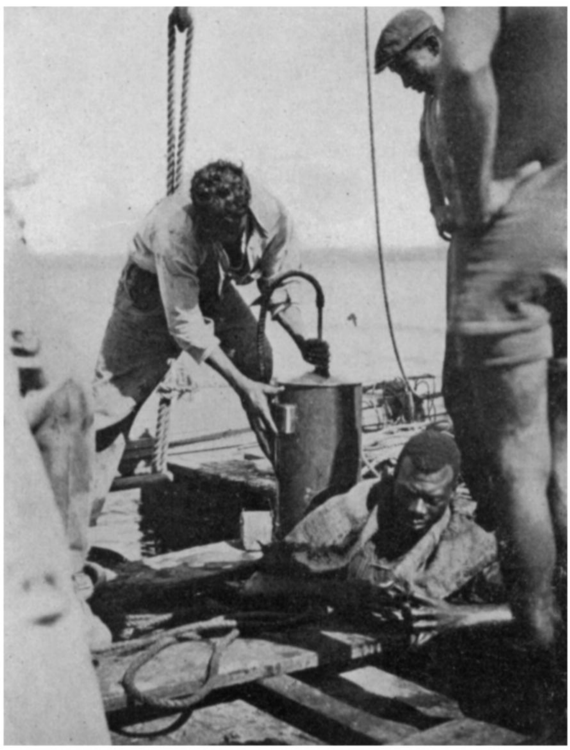
Catamaran Employed in Laying Submerged Pipe



Pipe on the Ways of the Catamaran

pended near its upper end from a Jennywink or light framed derrick on one of the lighters. To the cradle were attached sufficient barrel floats to make it nearly buoyant when supporting the pipe.

The length of the cradle with its tail planks was finally made 100 feet, sufficient to reach the bottom at a slope of about 14 degrees. This length was at first not so great, but later was made so.



HELMET USED IN DIVING

The pipes lay net 6 feet. For submerged use they were tested again on the ground, eliminating about 40 pieces out of the 2400 laid under the water, or 1 in 60. The joints were smeared with red lead. The ears, of course, were kept in a horizontal position, so as to permit vertical deflection in the pipe. The bolts were enveloped in a mixture of crude oil and cement held in place by muslin.

The use of red lead was adopted on the joints for subaqueous work. It has been found that red lead adheres better than white

for wet work. For earth trenches white lead was used. The bolts on land were protected by lean cement-sand mortar and bound in muslin. This was because the trenches were shallow and organic material was likely to rust the bolts rapidly.

The position of the catamaran was manipulated and maintained by six lines, two each forward, aft and abreast, while alignment was maintained by tall ranges on shore. Progress was quite rapid as a rule. To guard against accident from squalls, the cradle and pipe were lowered each night and noon, whenever the work was suspended. Work began August 24, 1916, and the last pipe was laid October 19, 1916. The number of working days was 47 in laying 14,400 feet of pipe. The average per day was 306 feet. The biggest day's work was 600 feet, and for one week 2982 feet.

At intervals of about 100 pieces, a water test was applied by means of a hand pump. When about 7000 feet had been laid the test failed to show a pressure on the guage. Air was then applied and two or three issues located. Work was not arrested, but a diver was sent for to make an examination. While waiting for the arrival of the diver, the pipe laying was finished.

The air issues indicated accurately the situation of the broken pipes. There proved to be seven in all. Of these two were in pipe split lengthwise and five where there were annular cracks at the shoulder of the toolwork against the rough iron. These fractures were probably due to too much deflection in tailing off from the cradle to the bottom in the case of pipe laid before the cradle was lengthened. It is also probable that the sea chop at times produced a compression on the side of some joints at the tail of the cradle.

It was demonstrated in the repairs that single pipes were easily removed. The oil cement mortar for protecting the bolts against rusting rendered the removal easy and lifting two pieces each way from the defective one sufficed to liberate the latter and admit the new pipe.

The experience herein recounted of the use of this joint indicates a possibility in laying submerged lines with greater economy than has been thought possible for similar situations. It is believed that it is possible to lay this pipe in certain submerged situations up to the limit of the sizes where only a single pair of ears are required.

Attention should be called to the favorable circumstances obtaining as to bedding of the pipe in this instance. The sea bottom is a

pure bed of ooze into which the pipe sank for nearly its full diameter in the process of laying. The bed is, therefore, one ideally prepared by nature. The lightness of the pipe lengths for transporting was an important factor. The facility for jointing in this region of crude help and adverse weather was also a favorable circumstance. This feature was likewise appreciated in the land portions, where swamp and declivity presented difficulties in handling heavy pieces.

It has been mentioned that several pipes split along the barrel and had to be removed after being inserted and tested. The experience gained in using this pipe, both here and in other foreign locations, where several handlings are entailed by ship's slings, etc., leads the author to believe that the cost of such testing is justified. The cost amounted in this case to about 1.6 cents per running foot on 15,000 feet of 8-inch pipe, which sum is not a serious factor. The author would not be understood as favoring greater caution in regard to this pipe than with any other manufactured for use in similar circumstances. The handling by ship's slings is always a severe test on any fragile material, and the fact that the smaller weight of individual pieces permits handling them in nets means that they receive a rather heavy hammering.

Among the illustrations is one showing the simple head piece which constituted the diver's equipment. A negro laborer on the work was broken in to make the repairs, but the foreman in charge himself inspected each replaced joint.

The final air test was 60 pounds, initial pressure, which in 24 hours reduced to 40 pounds.

The cost of the labor on the 14,400 foot submerged portion of the work is approximately given in Table 1.

TABLE 1

Cost of laying 14,400 feet of submerged pipe

	COST	COST PER FOOT
Pipe testing, handling and laying	$1,600.00	$0.1111
Hire of launch	320.00	.0222
Building cradle	100.00	.0069
Repairs and preparation of catamaran	150.00	.0104
Storing of plant after finishing job	150.00	.0104
Replacing defective pipe, line tests, etc., (includes about $350 expenses for diver and helper sent from the United States but not retained)	900.00	.0625
Total	$3,220.00	$0.2235

The extraordinary amount for repairs is illustrative of the expense due to delays in getting together special appliances when work is conducted in remote situations. In the total not only was the diver's expense a large item, but air pumps and power for testing out was considerable, and overhead expense was, of course, a continuing item.

The author was not present during the construction and the work was done under the direction of Alfred Clark, general manager of the railroad company. Carl Riggs was in general charge and constructed the land line; William J. Riggs had immediate charge of the submerged line and inspected all the joint repairs, using the head helmet; the successful completion of the work is largely due to them. Charles Schubel represented the Central Foundry Company.